EVALUATION OF MERCURY EMISSIONS DATA FOR CROSS GENERATING STATION

1.1 OVERVIEW

On June 30, 2008, Santee Cooper submitted to the South Carolina Department of Health and Environmental Control (DHEC) a Case-by-Case MACT Permit Application for the proposed Pee Dee generating units. The MACT Permit Application included a comprehensive review and analysis of all available information that is relevant for evaluating the mercury emissions levels that are achieved in practice by all similar sources – specifically all bituminous coal-fired pulverized coal electric utility steam generating units (EUSGUs).

Santee Cooper's MACT Permit Application, however, did not include a detailed analysis of mercury data that is available for the bituminous coal-fired units located at Santee Cooper's Cross Generating Station (CGS) in Berkeley County, South Carolina. Units 1 and 2 at CGS are pulverized coal boilers with a designed heat input rate of 5,200 MMBtu/hr. Both Units 1 and 2 at CGS are controlled by selective catalytic reduction (SCR), an electrostatic precipitator (ESP), and a wet scrubber. Additionally, both have mercury continuous emission monitoring systems (CEMS) which have collected mercury data over the past year.

Although CEMS data have been collected for CGS Units 1 and 2, it is important to note fundamental differences exist between the CEMS data available for these units and the stack test data that Santee Cooper used for the case-by-case MACT analysis for other similar sources (results from stack tests were gathered by the Environmental Protection Agency in its 1999 Information Collection Request [ICR] for the 2004 Utility MACT proposal for coal-fired EUSGUs). These differences preclude Santee Cooper from formally including the CEMS data in setting the MACT floor levels for mercury that were developed in the Pee Dee MACT application. Key discrepancies in the data set are highlighted here:

- There are inherent differences in the accuracy, precision and reliability of the Ontario-Hydro stack testing used for the ICR stack testing and that of CEMS measurements. Given that the mercury CEMS technology is still in the early stages of development and deployment, the current generation of mercury CEMS is much less precise, accurate, reliable than SO_2 and NO_x CEMS that have deployed for virtually all new and existing electric generating unit for over a decade. This is clearly reflected, as noted below in section 1.1.1, in the large difference (almost 75% difference) in measured mercury levels between Ontario-Hydro stack test method and the CEMS for CGS unit 1. In addition, mercury emissions collected through CEMS technology is inherently less precise, accurate, reliable than such data collected through the Ontario-Hydro stack testing, particularly in the case of low-emitting mercury units, such as CGS units 1 and 2.
- The CEMS data available only measure controlled mercury emissions, whereas the ICR data included controlled and uncontrolled mercury emissions tests.
- Much of the CEMS data currently available cannot be directly correlated to coal samples with as-fired mercury concentrations of the fuel, as in the ICR data. In the absence of

measured uncontrolled emissions, measurement of the mercury content of coal as-fired is essential to understanding emissions variability at units which are candidates for the "best performing" unit. Such emissions variability analysis is a necessary component of the MACT floor analysis.

- The CGS Unit 1 and Unit 2 CEMS only measure gaseous-phase mercury, and do not include the particulate-bound mercury fraction. As discussed in Section 1.1.4, below, we have used particulate mercury emissions from CGS Unit 3, as measured during two stack tests conducted in April 2008, as a surrogate for the particulate mercury levels at CGS Unit 1 and Unit 2. This adjustment gives a sense for what the full mercury emissions at CGS Unit 1 and Unit 2 might have been, but it does not establish what they actually were.

Although CEMS data are unsuitable for formal inclusion in the MACT analysis for the Pee Dee units, this report nonetheless presents for DHEC's reference the CEMS mercury data collected for the CGS Units 1 and 2. Furthermore, the report presents a reasonable approach to evaluating the available Cross data to assess the mercury emissions levels that were achieved in practice under the full range of foreseeable conditions. This analysis demonstrates that even if the CEMS data were suitable for use in the MACT analysis, their use would not have changed the basic outcome of the Pee Dee MACT floor analysis.

1.1.1 CEMS DATA ACCURACY

In order to address the understanding of the differences in accuracy between the CEMS data and the Ontario-Hydro stack testing, the CEMS data can be adjusted based on the direct comparison between the two during the most recent Relative Accuracy Test Audit (RATA) in September 2007 for the CGS Units 1 and 2 CEMS. The RATA presents the results of the American Society for Testing and Materials (ASTM) Reference Method D-6784-02 (Ontario-Hydro) stack test used for the ICR, while recording CEMS data simultaneously. The results of these RATA for the CGS Units 1 and 2 CEMS are delineated in the following table.

TABLE 1. CGS UNIT 1 AND UNIT 2 MERCURY CEMS RATA

Unit	Relative Accuracy	Absolute Difference	Avg Reference Method Hg Emissions (µg/m^3)	Avg. CEMS Hg Emissions (µg/m^3)
CGS – Unit 1[1]	72.7%	0.17	0.26	0.09
CGS – Unit 2[2]	5.1%	0.01	0.49	0.50

The RATA demonstrates that the CEMS for CGS Unit 1 measures substantially lower mercury emissions than the Ontario-Hydro stack test on the same stream at the same time, suggesting that in order to make a parallel comparison of the reported emissions from CGS Unit 1 to the population of similar sources tested in the ICR, the CEMS data must be adjusted according to its relative accuracy.[3]

In order to adjust the CEMS data for CGS Unit 1 according to its relative accuracy, a bias adjustment factor (BAF) was calculated in accordance with 40 CFR Part 75.[4] It should be noted that while a BAF has been applied in this analysis for CGS Unit 1 due to the large difference in measured mercury between the reference method and the CEMS for that unit, a BAF has not been applied to the CGS Unit 2. This is supported by the large underestimation of the CEMS for CGS Unit 1, while the CEMS for CGS Unit 2 has measurements more in-line with the reference method.

The following equation was utilized to develop the BAF for the CEMS on CGS Unit 1:[5]

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[1] *Relative Accuracy Test Audit Report For Santee Cooper – Cross Generating Station Pineville, South Carolina*. "Unit 1 – Mercury CEMS", Integrity Project No. 07-052, Performed: September 24-28, 2007.

[2] *Relative Accuracy Test Audit Report For Santee Cooper – Cross Generating Station Pineville, South Carolina*. "Unit 2 – Mercury CEMS", Integrity Project No. 07-052, Performed: September 24-26, 2007.

[3] As stated in the RATA report, "According to Section 13.4 of PS-12A, the relative accuracy of the CEMS must be no greater than 20 percent of the mean value of the reference method test data in terms of units of µg/m^3. Alternatively, if the mean reference method is less than 5.0 µg/m^3, the results are acceptable if the absolute value of the difference between the mean reference method and CEMS values does not exceed 1.0 µg/m^3". Because the results of the CGS Unit 1 reference method were less than 5.0 µg/m^3 and the absolute difference was 0.17, the results of the RATA were acceptable, even though the relative accuracy was much greater than 20%.

[4] 40 CFR §75, Appendix B – Quality Assurance and Quality Control Procedures, *2.3.4 Bias Adjustment Factor*.

[5] Equation A-12 of 40 CFR §75, Appendix A – Specifications and Test Procedures, *7.6.5 Bias Adjustment*.

$$BAF = 1 + \frac{\left|\overline{d}\right|}{CEM_{avg}}$$

Where

BAF = bias adjustment factor
$\left|\overline{d}\right|$ = absolute value of the arithmetic mean of the difference obtained during the bias test
CEM_{avg} = Mean of the data values provided by the monitor during the bias test.

Applying the values obtained during the September RATA for the CGS Unit 1 CEMS, the BAF is calculated to be

$$2.91 = 1 + \frac{|0.17|}{0.09}$$

By multiplying the results of the CGS Unit 1 CEMS by this value, or 2.91, the adjusted mercury emissions are more appropriate to compare to the results of the Ontario-Hydro stack tests at other similar sources.

1.1.2 MERCURY REMOVAL: UNCONTROLLED VERSUS CONTROLLED EMISSIONS MEASUREMENTS

Another limitation of the CGS CEMS data when compared to the stack testing in the 1999 ICR-3 database is that the CGS Unit 1 and Unit 2 CEMS only measure outlet mercury concentrations. The Ontario-Hydro stack testing performed for the ICR provides measured mercury emissions before and after the last control device for each unit, providing a basis to calculate mercury removal rates for the control configuration. This calculated mercury removal rate is relied upon to determine the emissions at the best controlled similar source under the worst foreseeable conditions, as described in detail in the approaches to calculating variability, both the EPA-NACAA and the EPA-DOE prongs outlined in the Pee Dee Case-by-Case MACT Permit Application.

With only outlet concentrations from CGS CEMS, a conservative comparison to the mercury content in the as-fired coal can be made, where available. Santee Cooper has collected coal samples prior to the coal being fed into the coal silos for both CGS Unit 1 and CGS Unit 2 approximately once per week while operating since the beginning of calendar year 2008. The measured mercury concentration of these coal samples can approximate "as-fired" for the week following the sample.[6] As such, it may be appropriate to compare the uncontrolled mercury emissions, conservatively calculated as the mercury content in the coal, to the weekly average CEMS measurements for controlled mercury emissions, after adjusting for bias. The following

[6] Coal being fed into the silos will be combusted within forty-eight to seventy-two hours, under normal operating conditions.

table presents the results of the coal samples and bias-adjusted weekly average CEMS concentrations.

TABLE 2. CGS COAL SAMPLES AND WEEKLY AVERAGE CEMS RESULTS

Date	CGS Unit 1		CGS Unit 2	
	Mercury Concentration in Coal (ppb, as received)	**CEMS Weekly Avg Mercury Emissions ($\mu g/m^3$)[7]**	**Mercury Concentration in Coal (ppb, as received)**	**CEMS Weekly Avg Mercury Emissions ($\mu g/m^3$)[8]**
1/7/2008	102	0.026	102	0.172
1/31/2008	89	0.215	91	0.215
2/7/2008	77	0.034	73	0.104
2/14/2008	136	0.034	130	0.247
2/22/2008	141	0.237	117	0.426
2/29/2008	87	0.419	79	0.249
3/14/2008	117	0.891	112	0.373
3/21/2008	No sample taken	Not operating	124	0.205
3/31/2008	No sample taken	Not operating	92	0.203
4/7/2008	No sample taken	Not operating	95	0.259
4/14/2008	No sample taken	Not operating	99	0.180
4/21/2008	No sample taken	Not operating	104	0.268
4/30/2008	No sample taken	Not operating	109	0.204
5/7/2008	89	0.696	107	0.138
5/14/2008	108	0.333	120	0.201
5/21/2008	94	0.421	102	0.163
5/31/2008	108	0.159	130	0.160
6/7/2008	103	0.161	92	0.161
6/14/2008	112	0.011	121	0.191

The coal samples and monitored values presented above allow a comparison to be made between a conservative estimate of the mercury entering the air pollution controls and the weekly average monitored values in the exhaust at the outlet of the controls. By utilizing these data as presented later in this analysis, an estimate of approximate removal rates can be calculated to provide a reasonable comparison to the data in the ICR.

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[7] The CEMS Weekly Average was calculated including all valid data, adjusting each measured concentration according to a BAF of 2.91. Measured values of zero were included in the weekly average without additional adjustment.

[8] The CEMS Weekly Average was calculated including all valid data. Measured values of zero were included in the weekly average without additional adjustment. No adjustment was made for relative accuracy.

The mercury concentrations presented in Table 2 also make it apparent that mercury concentration in the exhaust of CGS units, as measured by the CEMS, varies significantly even when averaged over a week. The maximum weekly average in the first part of the year is over eighty (80) times greater than the minimum value for CGS Unit 1. This demonstration of wide fluctuation in measured values, even when monitored data is adjusted for bias and averaged over a time period, supports that it is necessary to incorporate variability when establishing an achievable limit.

1.1.3 COAL SAMPLES

The 1999 ICR-2 database includes over 40,000 coal samples taken at approximately 450 coal-fired power plants in 1999. This provides a robust data set to evaluate not only the worst foreseeable conditions for raw materials for a single unit, but also for the population of similar sources. This large data set of coal samples measured for mercury reflects deliveries for entire power plants and therefore is not available for CGS Unit 1 or Unit 2 alone, and does not correlate with the emissions data recorded in 2008. However, a significant number of 2008 coal samples have been analyzed for mercury content and other characteristics for all of Santee Cooper's bituminous coal-fired units. Coal samples collected in calendar year 2008 and tested for mercury at CGS Units 1, 2, and 3, Grainger Generating Station Units 1 and 2, Jefferies Generating Station Units 3 and 4, and Winyah Generating Station Units 1, 2, 3, and 4 have been included in the analysis of raw material variability for CGS Unit 1 and Unit 2. Specifically, all bituminous coal samples tested for mercury at these units listed in Santee Cooper's fleet were considered as a possible worst-case fuel that could be fired in either CGS Unit 1 or Unit 2, when defining a worst-foreseeable operating condition.

The inclusion of coal delivered to these other sources is supported in that Santee Cooper purchases coal not for a single source, but for their entire fleet, distributing the coal to the individual sites based not on mercury concentration, but on other specifications (e.g., sulfur content). As such, it is reasonable to assume that any of the measured mercury concentrations going to any of these individual generating units could have been instead directed to CGS Unit 1 or Unit 2.

1.1.4 PARTICULATE MERCURY

In addition to the discrepancies between the data sources reviewed above, it is important to note that the CEMS on CGS Unit 1 and Unit 2 only measure the mercury fraction in the exhaust that is in the gaseous phase. Emissions of particulate-bound mercury (Hg_p) are not captured by the CEMS, as they are in the Ontario-Hydro stack test. As such, the mercury values measured by the CEMS may consistently underestimate total mercury emissions.

In order to draw a parallel comparison to the stack testing in the ICR, it is reasonable to add an estimated particulate mercury fraction to the CEMS data to account for total mercury emissions from the stack. Using the speciated results of the Ontario-Hydro stack testing conducted on the similar CGS Unit 3 on April 16, and 18, 2008, a value of 0.08 lb μg of Hg^{PM}/m^3 has been added to the results of the CEMS data in determining the total adjusted mercury emissions from each unit, CGS Unit 1 and Unit 2.[9]

1.1.5 ACCOUNTING FOR VARIABILITY

By acknowledging the discrepancies between the CEMS data at CGS and the stack test data available from other similar sources, and adjusting for the differences through the reasonable approaches described in this report, an approximate parallel comparison can be made between the data sets in determining the best performing source under the worst foreseeable conditions. After applying these adjustments, the CEMS data from CGS Unit 1 and Unit 2, and the corresponding mercury in coal are summarized in the following table.

[9] Memorandum from Bob Jongleux, URS Corporation, to Julie Metts, Santee Cooper, regarding "Ontario Hydro – Speciated Mercury Test Results from the Cross Station #3 Stack Location," dated May 22, 2008.

TABLE 3. ADJUSTED CGS COAL SAMPLES AND WEEKLY AVERAGE CEMS RESULTS

Date	CGS Unit 1 Mercury Concentration in Coal (lb/TBtu)[10]	CGS Unit 1 CEMS Weekly Avg Mercury Emissions (lb/TBtu)[11]	CGS Unit 2 Mercury Concentration in Coal (lb/TBtu)[12]	CGS Unit 2 CEMS Weekly Avg Mercury Emissions (lb/TBtu)[13]
1/7/2008	8.16	0.141	8.16	0.286
1/31/2008	7.12	0.284	7.28	0.238
2/7/2008	6.16	0.161	5.84	0.214
2/14/2008	10.9	0.157	10.4	0.386
2/22/2008	11.3	0.440	9.36	0.537
2/29/2008	6.96	0.597	6.32	0.392
3/14/2008	9.36	1.308	8.96	0.541
3/21/2008	No sample taken	Not operating	9.92	0.350
3/31/2008	No sample taken	Not operating	7.36	0.239
4/7/2008	No sample taken	Not operating	7.6	0.582
4/14/2008	No sample taken	Not operating	7.92	0.313
4/21/2008	No sample taken	Not operating	8.32	0.486
4/30/2008	No sample taken	Not operating	8.72	0.262
5/7/2008	7.12	1.096	8.56	0.275
5/14/2008	8.64	0.596	9.6	0.347
5/21/2008	7.52	0.651	8.16	0.287
5/31/2008	8.64	0.301	10.4	0.210
6/7/2008	8.24	0.314	7.36	0.293
6/14/2008	8.96	0.122	9.68	0.344

[10] Calculated assuming each coal sample has a heating value of 12,500 Btu/lb.

[11] The CEMS Weekly Average was calculated including all valid data, adjusting each measured concentration according to a BAF of 2.91. Measured values of zero were included in the weekly average without additional adjustment. The conversion to lb/TBtu utilized the measured average hourly flow rate in the stack during the corresponding week, and the total tons of coal burned in the week, assuming the coal had an average heating value of 12,500 Btu/lb. A value of 0.08 lb μg of Hg^{PM}/m^3 was added to these results to represent the particulate-bound mercury fraction.

[12] As with CGS Unit 1, the mercury content of the coal was calculated assuming each coal sample has a heating value of 12,500 Btu/lb.

[13] The CEMS Weekly Average was calculated including all valid data. Measured values of zero were included in the weekly average without additional adjustment. No adjustment was made for relative accuracy. The conversion to lb/TBtu utilized the measured average hourly flow rate in the stack during the corresponding week, and the total tons of coal burned in the week, assuming the coal had an average heating value of 12,500 Btu/lb. A value of 0.08 lb μg of Hg^{PM}/m^3 was added to these results to represent the particulate-bound mercury fraction.

Both the EPA-NACAA and EPA-DOE approaches to accounting for emissions variability were applied to the adjusted CEMS data for CGS Unit 1 and Unit 2, as delineated in the Case-by-Case MACT Permit Application dated June 30, 2008. For the EPA-NACAA approach, raw material variability was applied as the 97.5^{th} percentile worst-case coal that could be delivered to that source, as with the other sources from the ICR reviewed in the Permit Application. As noted in Section 1.1.3 above, coal samples from shipments to all of Santee Cooper's bituminous coal-fired units were considered as possibly being delivered to the CGS Units in the evaluation of the worst-case coal. The EPA-DOE approach was applied to the CGS Unit 1 and Unit 2 using the same methodology for which it was applied to the ICR sources in the Permit Application (Consideration of the 97.5^{th} percentile worst-case coal from the ICR-2 database). The results of these variability approaches are presented in Table 4 below.

TABLE 4. CGS UNIT 1 AND UNIT 2 ESTIMATES UNDER WORST-FORESEEABLE CONDITIONS

Source	EPA – NACAA Approach (lb/TBtu)	EPA – DOE Approach (lb/TBtu)	Worst Foreseeable Conditions (lb/TBtu)
CGS Unit 1	1.8375	1.3944	1.8375
CGS Unit 2	0.8670	1.0146	1.0146

Based on the heat rate conversion used by EPA in the 2004 Utility MACT proposal, the emissions rate under the worst-foreseeable conditions estimated by this analysis are 18 $x10^{-6}$ lb/MWh, gross and 10 $x10^{-6}$ lb/MWh, gross for CGS Unit 1 and Unit 2, respectively.

It should be stressed that the CEMS data utilized in this analysis are inherently different than that summarized by the ICR, as noted throughout this report. Although CEMS data are unsuitable for formal inclusion in the MACT analysis for the Pee Dee units, the results of this reasonable comparison affirm that even if the CEMS data were suitable for use in the MACT analysis, their use would not have changed the basic outcome of the Pee Dee MACT floor analysis.

The Clover Unit 2 should still be considered the MACT Floor with an emissions rate of 10 $x10^{-6}$ lb/MWh, gross.